

We claim:

- I. A video detection apparatus adapted to detect and follow movement of a predefined object of interest within the video data of the output of a video camera encoded in frame-wise data, each frame occurring at sequential time intervals, and including the segmentation of at least one portion of the frame-wise data, an object segment, as potentially including the preselected object of interest, and including vertical edge pixels and horizontal edge pixels detected to be present within the object segment, comprising:
  - an edge symmetry detection unit comprising:
    - a vertical symmetry detector adapted to compute the vertical symmetry of at least one of the set of vertical edge pixels and the set of horizontal edge pixels in each column about a horizontal axis passing through the object segment, and to produce a vertical symmetry value for columns within the object segment;
    - a horizontal symmetry detector adapted to compute the horizontal symmetry of at least one of the set of vertical edge pixels and set of horizontal edge pixels in each row about a vertical axis passing through the object segment, and to produce a horizontal symmetry value for rows within the object segment; and,
  - an edge symmetry feature set computation apparatus adapted to compute an edge symmetry feature set for the object segment based upon the vertical symmetry values and the horizontal symmetry values; and,
  - a background modeling unit comprising:
    - a background modeling apparatus adapted to isolate from a current frame at least one segment of the current frame, each of the at least one segments containing a possible object of interest within the current frame, on a frame-wise basis, and to provide as an output each of the at least one segments;
    - an object of interest classifying apparatus adapted to determine whether or not any segment of the at least one segments output from the background

modeling apparatus includes a object of interest and to characterize any such segment as an object segment, utilizing at least in part the edge symmetry feature set;  
an object segment tracking apparatus adapted to track the location within  
5 the current frame of any object segment, and to determine a projected location of the object segment in a subsequent frame, and to provide the background modeling apparatus with the projected location in the subsequent frame of the object segment; and  
wherein the background modeling apparatus is adapted to provide as its  
10 output the projected location of the object segment in the subsequent frame in lieu of a segment from the subsequent frame determined by the background modeling apparatus to contain a possible object of interest or in the event that the background modeling apparatus is unable in the subsequent frame to locate any segment containing a possible object of  
15 interest.

2. The apparatus of claim 1, further comprising:

the edge symmetry unit further comprising:  
a vertical symmetry detector adapted to compute the vertical symmetry of  
20 the set of vertical edge pixels and the set of horizontal edge pixels in each column about a horizontal axis passing through the object segment, and to produce a vertical symmetry value for columns within the object segment;  
a horizontal symmetry detector adapted to compute the horizontal symmetry of set of vertical edge pixels and set of horizontal edge pixels in  
25 each row about a vertical axis passing through the object segment, and to produce a horizontal symmetry value for rows within the object segment;  
a feature set computation apparatus adapted to compute a feature set for the object segment based upon the vertical symmetry values and the horizontal symmetry values.

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3. The apparatus of claim 2, further comprising:

the object segment tracking apparatus further comprising:

a matching apparatus adapted to match the location of an object segment in the current frame to one of a plurality of projected locations of the object segment in the current frame, which projections are based upon the location of the respective object segment in at least one prior frame; and,

5 a track provider adapted to receive and store the location of an object segment in the current frame and over a plurality of prior frames and adapted to provide the projections of the location of the object segment in a subsequent frame based upon the locations of the object segments in the current frame and the plurality of prior frames.

4. The apparatus of claim 3, further comprising:

the vertical symmetry detector is adapted to compute the vertical symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given column  $i$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each column  $i$  on opposing sides of the horizontal axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the horizontal axis;

the horizontal symmetry detector is adapted to compute the horizontal symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given row  $j$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each row  $j$  on opposing sides of the vertical axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge pixels or no vertical edge pixels, respectively, on either side of the horizontal

axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the vertical axis.

5. The apparatus of claim 4, further comprising:

5       the background modeling apparatus is adapted to provide as its output the projected location of the object segment in the subsequent frame in order to override any conflict in the labeling of pixels in the subsequent frame as part of a segment containing a possible object of interest.

10   6. The apparatus of claim 5, further comprising:

      the feature set computation apparatus further comprising:  
      a horizontal fuzzy set computation apparatus adapted to compute a fuzzy set value for each of a plurality of horizontal fuzzy sets each having a selected weighting function applicable to a selected group of columns  
15       within the object segment, with the columns grouped according to position along the horizontal axis in the object segment; and  
      a vertical fuzzy set computation apparatus adapted to compute a fuzzy set value for each of a plurality of vertical fuzzy sets each having a selected weighting function applicable to a selected group of rows within the object  
20       segment, with the rows grouped according to position along the vertical axis in the object segment.

7. The apparatus of claim 6, further comprising:

      the background modeling apparatus is adapted to isolate from a current  
25       frame the at least one segment of the current frame utilizing the video object plane extracted from the current frame.

8. The apparatus of claim 7, further comprising:

      the horizontal fuzzy sets further comprising:  
30       a left extreme fuzzy set having a weighting function that is a constant value

- for a first selected number of columns from the left border of the object segment toward the vertical axis of the object segment and decreases to zero over a second selected number of columns toward the vertical axis if the object segment;
- 5 a right extreme fuzzy set having a weighting function that is a constant value for a third selected number of columns from the right border of the object segment toward the vertical axis of the object segment and decreases to zero over a fourth selected number of columns toward the vertical axis of the object segment; and
- 10 at least one horizontal internal fuzzy set having a weighting function that increases from zero to a peak value and decreases to zero as the columns contained in each such internal fuzzy set go from left to right across the object image; and,
- the vertical fuzzy sets further comprising:
- 15 a bottom extreme fuzzy set having a weighting function that is a constant value for a fifth selected number of rows from the bottom border of the object segment toward the horizontal axis of the object segment and decreases to zero over a sixth selected number of rows toward the horizontal axis if the object segment;
- 20 a top extreme fuzzy set having a weighting function that is a constant value for a seventh selected number of columns from the top border of the object segment toward the horizontal axis of the object segment and decreases to zero over an eighth selected number of rows toward the horizontal axis of the object segment; and,
- 25 at least one vertical internal fuzzy set having a weighting function that increases from zero to a peak value and decreases to zero as the rows contained in each such vertical internal fuzzy set go from bottom to top across the object image.
- 30 9. The apparatus of claim 8, further comprising:

the at least one segment of the current frame is a bounding box.

10. The apparatus of claim 9, further comprising:

- the columns associated with each of the horizontal fuzzy sets are
- 5 overlapping into respective adjacent horizontal fuzzy sets; and,
- the rows associated with each of the vertical fuzzy sets are overlapping into respective adjacent vertical fuzzy sets.

11. The apparatus of claim 10, further comprising:

- 10 the feature set computation apparatus further comprising a fuzzy set edge value score computing apparatus adapted to compute a fuzzy set edge value based upon the respective horizontal edge value or vertical edge value for the respective column or row and the respective horizontal fuzzy set weighting function value for the respective column or the respective vertical fuzzy set weighting function for the
- 15 respective row.

12. A video detection apparatus for detecting and following movement of a predefined object of interest within the video data of the output of a video camera encoded in frame-wise data, each frame occurring at sequential time intervals, and

20 including the segmentation of at least one portion of the frame-wise data, an object segment, as potentially including the preselected object of interest, and including vertical edge pixels and horizontal edge pixels detected to be present within the object segment, comprising:

- an edge symmetry detection means comprising:
- 25 a vertical symmetry detection means for computing the vertical symmetry of at least one of the set of vertical edge pixels and the set of horizontal edge pixels in each column about a horizontal axis passing through the object segment, and producing a vertical symmetry value for columns within the object segment;
- 30 a horizontal symmetry detection means for computing the horizontal

symmetry of at least one of the set of vertical edge pixels and set of horizontal edge pixels in each row about a vertical axis passing through the object segment, and producing a horizontal symmetry value for rows within the object segment; and,

5 an edge symmetry feature set computation means for computing an edge symmetry feature set for the object segment based upon the vertical symmetry values and the horizontal symmetry values; and,

a background modeling means comprising:

a background modeling means for isolating from a current frame at least

10 one segment of the current frame, each of the at least one segments containing a possible object of interest within the current frame, on a frame-wise basis, and providing as an output each of the at least one segments;

an object of interest classifying means for determining whether or not any segment of the at least one segments output from the background modeling

15 means includes a object of interest and for characterizing any such segment as an object segment, utilizing at least in part the edge symmetry feature set;

an object segment tracking means for tracking the location within the current frame of any object segment, and determining a projected location

20 of the object segment in a subsequent frame, and providing the background modeling means with the projected location in the subsequent frame of the object segment; and

wherein the background modeling means includes means for providing as its output the projected location of the object segment in the subsequent

25 frame in lieu of a segment from the subsequent frame determined by the background modeling means to contain a possible object of interest or in the event that the background modeling means is unable in the subsequent frame to locate any segment containing a possible object of interest.

30 13. The apparatus of claim 12, further comprising:

the edge symmetry unit further comprising:  
the vertical symmetry detection means is a means for computing the vertical symmetry of the set of vertical edge pixels and the set of horizontal edge pixels in each column about a horizontal axis passing through the object segment, and producing a vertical symmetry value for columns within the object segment;  
the horizontal symmetry detection means is a means for computing the horizontal symmetry of the set of vertical edge pixels and the set of horizontal edge pixels in each row about a vertical axis passing through the object segment, and producing a horizontal symmetry value for rows within the object segment.

14. The apparatus of claim 13, further comprising:

the object segment tracking means further comprising:  
a matching means for matching the location of an object segment in the current frame to one of a plurality of projected locations of the object segment in the current frame, which projections are based upon the location of the respective object segment in at least one prior frame; and,  
a track providing means for receiving and storing the location of an object segment in the current frame and over at least one of a plurality of prior frames and for providing the projections of the location of the object segment in a subsequent frame based upon the locations of the object segments in the current frame and at least one of the plurality of prior frames.

15. The apparatus of claim 14, further comprising:

the vertical symmetry detection means includes means for computing the vertical symmetry value of the set of horizontal edges and the set of vertical edges in a given column  $i$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each column  $i$  on opposing sides of the horizontal axis,



independent of which side has more horizontal edge pixels or vertical edge pixels,  
respectively, expressed as a number between 0, if there are no horizontal edge  
pixels or no vertical edge pixels, respectively, on either side of the horizontal axis  
and 1.0 if there are, respectively, an equal number of horizontal edge pixels or  
5 vertical edge pixels, respectively on both sides of the horizontal axis;

the horizontal symmetry detection means includes means for computing the  
horizontal symmetry value of the set of horizontal edges and the set of vertical  
edges in a given row  $j$  as the ratio of the number of horizontal edge pixels or  
vertical edge pixels, respectively, in each row  $j$  on opposing sides of the vertical  
10 axis, independent of which side has more horizontal edge pixels or vertical edge  
pixels, respectively, expressed as a number between 0, if there are no horizontal  
edge pixels or no vertical edge pixels, respectively, on either side of the horizontal  
axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or  
vertical edge pixels, respectively on both sides of the vertical axis.

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16. The apparatus of claim 15, further comprising:

the background modeling means including means for providing as its  
output the projected location of the object segment in the subsequent frame in order  
to override any conflict in the labeling of pixels in the subsequent frame as part of a  
20 segment containing a possible object of interest.

17. The apparatus of claim 16, further comprising:

the feature set computation means further comprising:  
a horizontal fuzzy set computation means for computing a fuzzy set value  
25 for each of a plurality of horizontal fuzzy sets each having a selected  
weighting function applicable to a selected group of columns within the  
object segment, with the columns grouped according to position along the  
horizontal axis in the object segment; and  
a vertical fuzzy set computation means for computing a fuzzy set value for  
30 each of a plurality of vertical fuzzy sets each having a selected weighting

function applicable to a selected group of rows within the object segment, with the rows grouped according to position along the vertical axis in the object segment.

5     18. The apparatus of claim 17, further comprising:

the background modeling means including means for isolating from a current frame the at least one segment of the current frame utilizing the video object plane extracted from the current frame.

10    19. The apparatus of claim 18, further comprising:

the horizontal fuzzy sets further comprising:

a left extreme fuzzy set having a weighting function that is a constant value for a first selected number of columns from the left border of the object segment toward the vertical axis of the object segment and decreases to  
15    zero over a second selected number of columns toward the vertical axis if the object segment;

a right extreme fuzzy set having a weighting function that is a constant value for a third selected number of columns from the right border of the object segment toward the vertical axis of the object segment and decreases  
20    to zero over a fourth selected number of columns toward the vertical axis of the object segment; and

at least one horizontal internal fuzzy set having a weighting function that increases from zero to a peak value and decreases to zero as the columns contained in each such internal fuzzy set go from left to right across the  
25    object image; and,

the vertical fuzzy sets further comprising:

a bottom extreme fuzzy set having a weighting function that is a constant value for a fifth selected number of rows from the bottom border of the object segment toward the horizontal axis of the object segment and  
30    decreases to zero over a sixth selected number of rows toward the

- horizontal axis of the object segment;  
a top extreme fuzzy set having a weighting function that is a constant value  
for a seventh selected number of columns from the top border of the object  
segment toward the horizontal axis of the object segment and decreases to  
5 zero over an eighth selected number of rows toward the horizontal axis of  
the object segment; and,  
at least one vertical internal fuzzy set having a weighting function that  
increases from zero to a peak value and decreases to zero as the rows  
contained in each such vertical internal fuzzy set go from bottom to top  
10 across the object image.
20. The apparatus of claim 19, further comprising:  
the at least one segment of the current frame isolated from the current frame  
by the background modeling means is a bounding box.  
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21. The apparatus of claim 20, further comprising:  
the columns associated with each of the horizontal fuzzy sets are  
overlapping into respective adjacent horizontal fuzzy sets; and,  
the rows associated with each of the vertical fuzzy sets are overlapping into  
20 respective adjacent vertical fuzzy sets.
22. The apparatus of claim 21, further comprising:  
the feature set computation means further comprising a fuzzy set edge value  
score computing means for computing a fuzzy set edge value based upon the  
25 respective horizontal edge value or vertical edge value for the respective column or  
row and the respective horizontal fuzzy set weighting function value for the  
respective column or the respective vertical fuzzy set weighting function for the  
respective row.
- 30 23. A video detection method for detecting and following movement of a

predefined object of interest within the video data of the output of a video camera encoded in frame-wise data, each frame occurring at sequential time intervals, and including the segmentation of at least one portion of the frame-wise data, an object segment, as potentially including the preselected object of interest, and including

5 vertical edge pixels and horizontal edge pixels detected to be present within the object segment, comprising:

- utilizing an edge symmetry detection unit:
  - computing the vertical symmetry of at least one of the set of vertical edge pixels and the set of horizontal edge pixels in each column about a
  - 10 horizontal axis passing through the object segment, and producing a vertical symmetry value for columns within the object segment;
  - computing the horizontal symmetry of at least one of the set of vertical edge pixels and set of horizontal edge pixels in each row about a vertical axis passing through the object segment, and producing a horizontal symmetry
  - 15 value for rows within the object segment; and,
  - computing an edge symmetry feature set for the object segment based upon the vertical symmetry values and the horizontal symmetry values; and,
  - utilizing a background modeling unit comprising:
    - isolating from a current frame at least one segment of the current frame,
    - 20 each of the at least one segments containing a possible object of interest within the current frame, on a frame-wise basis, and providing as an output each of the at least one segments;
    - determining whether or not any segment of the at least one segments output from the background modeling means includes a object of interest and for
    - 25 characterizing any such segment as an object segment, utilizing at least in part the edge symmetry feature set;
    - tracking the location within the current frame of any object segment, and determining a projected location of the object segment in a subsequent frame, and providing the background modeling means with the projected
    - 30 location in the subsequent frame of the object segment; and

wherein the background modeling unit includes means for providing as its output the projected location of the object segment in the subsequent frame in lieu of a segment from the subsequent frame determined by the background modeling means to contain a possible object of interest or in the event that the background modeling means is unable in the subsequent frame to locate any segment containing a possible object of interest.

24. The method of claim 23, further comprising:

the utilization of the edge symmetry unit further comprising:  
computing the vertical symmetry of the set of vertical edge pixels and the set of horizontal edge pixels in each column about a horizontal axis passing through the object segment, and producing a vertical symmetry value for columns within the object segment; and,  
computing the horizontal symmetry of the set of vertical edge pixels and the set of horizontal edge pixels in each row about a vertical axis passing through the object segment, and producing a horizontal symmetry value for rows within the object segment.

25. The method of claim 24, further comprising:

the utilization of the object segment tracking means further comprising:  
matching the location of an object segment in the current frame to one of a plurality of projected locations of the object segment in the current frame, which projections are based upon the location of the respective object segment in at least one prior frame; and,  
receiving and storing the location of an object segment in the current frame and over at least one of a plurality of prior frames and for providing the projections of the location of the object segment in a subsequent frame based upon the locations of the object segments in the current frame and at least one of the plurality of prior frames.

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26. The method of claim 25, further comprising:

computing the vertical symmetry value of the set of horizontal edges and the set of vertical edges in a given column  $i$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each column  $i$  on opposing sides of the horizontal axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the horizontal axis; and,

computing the horizontal symmetry value of the set of horizontal edges and the set of vertical edges in a given row  $j$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each row  $j$  on opposing sides of the vertical axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the vertical axis.

27. The method of claim 26, further comprising:

the background modeling means including means for providing as its output the projected location of the object segment in the subsequent frame in order to override any conflict in the labeling of pixels in the subsequent frame as part of a segment containing a possible object of interest.

28. The method of claim 27, further comprising:

computing a fuzzy set value for each of a plurality of horizontal fuzzy sets each having a selected weighting function applicable to a selected group of columns within the object segment, with the columns grouped according to position along the horizontal axis in the object segment; and

computing a fuzzy set value for each of a plurality of vertical fuzzy sets each having a selected weighting function applicable to a selected group of rows within the object segment, with the rows grouped according to position along the vertical axis in the object segment.

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29. The apparatus of claim 28, further comprising:

isolating from a current frame the at least one segment of the current frame utilizing the video object plane extracted from the current frame.

10 30. The method of claim 29, further comprising:

the horizontal fuzzy sets further comprising:

a left extreme fuzzy set having a weighting function that is a constant value for a first selected number of columns from the left border of the object segment toward the vertical axis of the object segment and decreases to zero over a second selected number of columns toward the vertical axis if the object segment;

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a right extreme fuzzy set having a weighting function that is a constant value for a third selected number of columns from the right border of the object segment toward the vertical axis of the object segment and decreases to zero over a fourth selected number of columns toward the vertical axis of the object segment; and

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at least one horizontal internal fuzzy set having a weighting function that increases from zero to a peak value and decreases to zero as the columns contained in each such internal fuzzy set go from left to right across the object image; and,

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the vertical fuzzy sets further comprising:

a bottom extreme fuzzy set having a weighting function that is a constant value for a fifth selected number of rows from the bottom border of the object segment toward the horizontal axis of the object segment and decreases to zero over a sixth selected number of rows toward the

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horizontal axis of the object segment;  
a top extreme fuzzy set having a weighting function that is a constant value  
for a seventh selected number of columns from the top border of the object  
segment toward the horizontal axis of the object segment and decreases to  
5 zero over an eighth selected number of rows toward the horizontal axis of  
the object segment; and,  
at least one vertical internal fuzzy set having a weighting function that  
increases from zero to a peak value and decreases to zero as the rows  
contained in each such vertical internal fuzzy set go from bottom to top  
10 across the object image.

31. The apparatus of claim 30, further comprising:  
the at least one segment of the current frame isolated from the current frame  
by the background modeling means is a bounding box.  
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32. The method of claim 31, further comprising:  
the columns associated with each of the horizontal fuzzy sets are  
overlapping into respective adjacent horizontal fuzzy sets; and,  
the rows associated with each of the vertical fuzzy sets are overlapping into  
20 respective adjacent vertical fuzzy sets.

33. The method of claim 32, further comprising:  
computing a fuzzy set edge value based upon the respective horizontal edge  
value or vertical edge value for the respective column or row and the respective  
25 horizontal fuzzy set weighting function value for the respective column or the  
respective vertical fuzzy set weighting function for the respective row.

34. A video detection apparatus adapted to detect and follow movement of a  
predefined object of interest within the video data of the output of a video camera  
30 encoded in frame-wise data, each frame occurring at sequential time intervals, and



including the segmentation of at least one portion of the frame-wise data, an object segment, as potentially including the preselected object of interest, and including vertical edge pixels and horizontal edge pixels detected to be present within the object segment, comprising:

- 5           an edge symmetry detection unit comprising:
  - a vertical symmetry detector adapted to compute the vertical symmetry of the set of vertical edge pixels and the set of horizontal edge pixels in each column about a horizontal axis passing through the object segment, and to produce a vertical symmetry value for columns within the object segment;
  - 10       a horizontal symmetry detector adapted to compute the horizontal symmetry of the set of vertical edge pixels and set of horizontal edge pixels in each row about a vertical axis passing through the object segment, and to produce a horizontal symmetry value for rows within the object segment;
  - and,
- 15       an edge symmetry feature set computation apparatus adapted to compute an edge symmetry feature set for the object segment based upon the vertical symmetry values and the horizontal symmetry values; and,
  - a background modeling unit comprising:
    - a background modeling apparatus adapted to isolate from a current frame at
    - 20       least one segment of the current frame, each of the at least one segments containing a possible object of interest within the current frame, on a frame-wise basis, and to provide as an output each of the at least one segments;
    - an object of interest classifying apparatus adapted to determine whether or not any segment of the at least one segments output from the background
    - 25       modeling apparatus includes a object of interest and to characterize any such segment as an object segment, utilizing at least in part the edge symmetry feature set;
    - an object segment tracking apparatus adapted to track the location within the current frame of any object segment, and to determine a projected
    - 30       location of the object segment in a subsequent frame, and to provide the

background modeling apparatus with the projected location in the subsequent frame of the object segment;  
wherein the background modeling apparatus is adapted to provide as its output the projected location of the object segment in the subsequent frame in lieu of a segment from the subsequent frame determined by the background modeling apparatus to contain a possible object of interest or in the event that the background modeling apparatus is unable in the subsequent frame to locate any segment containing a possible object of interest; and,  
the object segment tracking apparatus further comprising:  
a matching apparatus adapted to match the location of an object segment in the current frame to one of a plurality of projected locations of the object segment in the current frame, which projections are based upon the location of the respective object segment in at least one prior frame; and,  
a track provider adapted to receive and store the location of an object segment in the current frame and over a plurality of prior frames and adapted to provide the projections of the location of the object segment in a subsequent frame based upon the locations of the object segments in the current frame and the plurality of prior frames.

35. A video detection apparatus adapted to detect and follow movement of a predefined object of interest within the video data of the output of a video camera encoded in frame-wise data, each frame occurring at sequential time intervals, and including the segmentation of at least one portion of the frame-wise data, an object segment, as potentially including the preselected object of interest, and including vertical edge pixels and horizontal edge pixels detected to be present within the object segment, comprising:  
an edge symmetry detection unit comprising:  
a vertical symmetry detector adapted to compute the vertical symmetry of the set of vertical edge pixels and the set of horizontal edge pixels in each

column about a horizontal axis passing through the object segment, and to  
produce a vertical symmetry value for columns within the object segment;  
a horizontal symmetry detector adapted to compute the horizontal  
symmetry of the set of vertical edge pixels and set of horizontal edge pixels  
5 in each row about a vertical axis passing through the object segment, and to  
produce a horizontal symmetry value for rows within the object segment;  
and,  
an edge symmetry feature set computation apparatus adapted to compute an  
edge symmetry feature set for the object segment based upon the vertical  
10 symmetry values and the horizontal symmetry values; and,  
a background modeling unit comprising:  
a background modeling apparatus adapted to isolate from a current frame at  
least one segment of the current frame, each of the at least one segments  
containing a possible object of interest within the current frame, on a frame-  
15 wise basis, and to provide as an output each of the at least one segments;  
an object of interest classifying apparatus adapted to determine whether or  
not any segment of the at least one segments output from the background  
modeling apparatus includes a object of interest and to characterize any  
such segment as an object segment, utilizing at least in part the edge  
20 symmetry feature set;  
an object segment tracking apparatus adapted to track the location within  
the current frame of any object segment, and to determine a projected  
location of the object segment in a subsequent frame, and to provide the  
background modeling apparatus with the projected location in the  
25 subsequent frame of the object segment;  
wherein the background modeling apparatus is adapted to provide as its  
output the projected location of the object segment in the subsequent frame  
in lieu of a segment from the subsequent frame determined by the  
background modeling apparatus to contain a possible object of interest or in  
30 the event that the background modeling apparatus is unable in the

subsequent frame to locate any segment containing a possible object of interest; and,

the object segment tracking apparatus further comprising:

a matching apparatus adapted to match the location of an object segment in

5 the current frame to one of a plurality of projected locations of the object segment in the current frame, which projections are based upon the location of the respective object segment in at least one prior frame;

a track provider adapted to receive and store the location of an object segment in the current frame and over a plurality of prior frames and adapted to provide the

10 projections of the location of the object segment in a subsequent frame based upon the locations of the object segments in the current frame and the plurality of prior frames; and,

the vertical symmetry detector is adapted to compute the vertical symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a

15 given column  $i$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each column  $i$  on opposing sides of the horizontal axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis

20 and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the horizontal axis; and,

the horizontal symmetry detector is adapted to compute the horizontal symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given row  $j$  as the ratio of the number of horizontal edge pixels or

25 vertical edge pixels, respectively, in each row  $j$  on opposing sides of the vertical axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or

30 vertical edge pixels, respectively on both sides of the vertical axis.

36. A video detection apparatus adapted to detect and follow movement of a predefined object of interest within the video data of the output of a video camera encoded in frame-wise data, each frame occurring at sequential time intervals, and including the segmentation of at least one portion of the frame-wise data, an object segment, as potentially including the preselected object of interest, and including vertical edge pixels and horizontal edge pixels detected to be present within the object segment, comprising:

- an edge symmetry detection unit comprising:
  - a vertical symmetry detector adapted to compute the vertical symmetry of the set of vertical edge pixels and the set of horizontal edge pixels in each column about a horizontal axis passing through the object segment, and to produce a vertical symmetry value for columns within the object segment;
  - a horizontal symmetry detector adapted to compute the horizontal symmetry of the set of vertical edge pixels and set of horizontal edge pixels in each row about a vertical axis passing through the object segment, and to produce a horizontal symmetry value for rows within the object segment;
  - and,
  - an edge symmetry feature set computation apparatus adapted to compute an edge symmetry feature set for the object segment based upon the vertical symmetry values and the horizontal symmetry values; and,
- a background modeling unit comprising:
  - a background modeling apparatus adapted to isolate from a current frame at least one segment of the current frame, each of the at least one segments containing a possible object of interest within the current frame, on a frame-wise basis, and to provide as an output each of the at least one segments;
  - an object of interest classifying apparatus adapted to determine whether or not any segment of the at least one segments output from the background modeling apparatus includes a object of interest and to characterize any

such segment as an object segment, utilizing at least in part the edge symmetry feature set;

an object segment tracking apparatus adapted to track the location within the current frame of any object segment, and to determine a projected location of the object segment in a subsequent frame, and to provide the background modeling apparatus with the projected location in the subsequent frame of the object segment;

wherein the background modeling apparatus is adapted to provide as its output the projected location of the object segment in the subsequent frame in lieu of a segment from the subsequent frame determined by the background modeling apparatus to contain a possible object of interest or in the event that the background modeling apparatus is unable in the subsequent frame to locate any segment containing a possible object of interest; and,

the object segment tracking apparatus further comprising:

a matching apparatus adapted to match the location of an object segment in the current frame to one of a plurality of projected locations of the object segment in the current frame, which projections are based upon the location of the respective object segment in at least one prior frame;

a track provider adapted to receive and store the location of an object segment in the current frame and over a plurality of prior frames and adapted to provide the projections of the location of the object segment in a subsequent frame based upon the locations of the object segments in the current frame and the plurality of prior frames; and,

the vertical symmetry detector is adapted to compute the vertical symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given column  $i$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each column  $i$  on opposing sides of the horizontal axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge

pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the horizontal axis; and,

the horizontal symmetry detector is adapted to compute the horizontal symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given row  $j$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each row  $j$  on opposing sides of the vertical axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the vertical axis; and,

the background modeling apparatus is adapted to provide as its output the projected location of the object segment in the subsequent frame in order to override any conflict in the labeling of pixels in the subsequent frame as part of a segment containing a possible object of interest.

37. A video detection apparatus adapted to detect and follow movement of a predefined object of interest within the video data of the output of a video camera encoded in frame-wise data, each frame occurring at sequential time intervals, and including the segmentation of at least one portion of the frame-wise data, an object segment, as potentially including the preselected object of interest, and including vertical edge pixels and horizontal edge pixels detected to be present within the object segment, comprising:

an edge symmetry detection unit comprising:

a vertical symmetry detector adapted to compute the vertical symmetry of the set of vertical edge pixels and the set of horizontal edge pixels in each column about a horizontal axis passing through the object segment, and to produce a vertical symmetry value for columns within the object segment;

a horizontal symmetry detector adapted to compute the horizontal

symmetry of the set of vertical edge pixels and set of horizontal edge pixels  
in each row about a vertical axis passing through the object segment, and to  
produce a horizontal symmetry value for rows within the object segment;  
and,  
5 an edge symmetry feature set computation apparatus adapted to compute an  
edge symmetry feature set for the object segment based upon the vertical  
symmetry values and the horizontal symmetry values; and,  
a background modeling unit comprising:  
a background modeling apparatus adapted to isolate from a current frame at  
10 at least one segment of the current frame, each of the at least one segments  
containing a possible object of interest within the current frame, on a frame-  
wise basis, and to provide as an output each of the at least one segments;  
an object of interest classifying apparatus adapted to determine whether or  
not any segment of the at least one segments output from the background  
15 modeling apparatus includes a object of interest and to characterize any  
such segment as an object segment, utilizing at least in part the edge  
symmetry feature set;  
an object segment tracking apparatus adapted to track the location within  
the current frame of any object segment, and to determine a projected  
20 location of the object segment in a subsequent frame, and to provide the  
background modeling apparatus with the projected location in the  
subsequent frame of the object segment;  
wherein the background modeling apparatus is adapted to provide as its  
output the projected location of the object segment in the subsequent frame  
25 in lieu of a segment from the subsequent frame determined by the  
background modeling apparatus to contain a possible object of interest or in  
the event that the background modeling apparatus is unable in the  
subsequent frame to locate any segment containing a possible object of  
interest; and,  
30 the object segment tracking apparatus further comprising:



a matching apparatus adapted to match the location of an object segment in the current frame to one of a plurality of projected locations of the object segment in the current frame, which projections are based upon the location of the respective object segment in at least one prior frame;

5 a track provider adapted to receive and store the location of an object segment in the current frame and over a plurality of prior frames and adapted to provide the projections of the location of the object segment in a subsequent frame based upon the locations of the object segments in the current frame and the plurality of prior frames; and,

10 the vertical symmetry detector is adapted to compute the vertical symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given column  $i$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each column  $i$  on opposing sides of the horizontal axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge

15 pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the horizontal axis; and,

the horizontal symmetry detector is adapted to compute the horizontal

20 symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given row  $j$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each row  $j$  on opposing sides of the vertical axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal

25 edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the vertical axis;

the background modeling apparatus is adapted to provide as its output the projected location of the object segment in the subsequent frame in order to

30 override any conflict in the labeling of pixels in the subsequent frame as part of a

segment containing a possible object of interest; and,

the feature set computation apparatus further comprising:

a horizontal fuzzy set computation apparatus adapted to compute a fuzzy set value for each of a plurality of horizontal fuzzy sets each having a

5 selected weighting function applicable to a selected group of columns within the object segment, with the columns grouped according to position along the horizontal axis in the object segment; and,

a vertical fuzzy set computation apparatus adapted to compute a fuzzy set value for each of a plurality of vertical fuzzy sets each having a selected  
10 weighting function applicable to a selected group of rows within the object segment, with the rows grouped according to position along the vertical axis in the object segment.

38. A video detection apparatus adapted to detect and follow movement of a  
15 predefined object of interest within the video data of the output of a video camera encoded in frame-wise data, each frame occurring at sequential time intervals, and including the segmentation of at least one portion of the frame-wise data, an object segment, as potentially including the preselected object of interest, and including vertical edge pixels and horizontal edge pixels detected to be present within the  
20 object segment, comprising:

an edge symmetry detection unit comprising:

a vertical symmetry detector adapted to compute the vertical symmetry of the set of vertical edge pixels and the set of horizontal edge pixels in each column about a horizontal axis passing through the object segment, and to  
25 produce a vertical symmetry value for columns within the object segment;  
a horizontal symmetry detector adapted to compute the horizontal symmetry of the set of vertical edge pixels and set of horizontal edge pixels in each row about a vertical axis passing through the object segment, and to produce a horizontal symmetry value for rows within the object segment;

30 and,

an edge symmetry feature set computation apparatus adapted to compute an edge symmetry feature set for the object segment based upon the vertical symmetry values and the horizontal symmetry values; and,  
a background modeling unit comprising:  
5 a background modeling apparatus adapted to isolate from a current frame at least one segment of the current frame, each of the at least one segments containing a possible object of interest within the current frame, on a frame-wise basis, and to provide as an output each of the at least one segments;  
an object of interest classifying apparatus adapted to determine whether or  
10 not any segment of the at least one segments output from the background modeling apparatus includes a object of interest and to characterize any such segment as an object segment, utilizing at least in part the edge symmetry feature set;  
an object segment tracking apparatus adapted to track the location within  
15 the current frame of any object segment, and to determine a projected location of the object segment in a subsequent frame, and to provide the background modeling apparatus with the projected location in the subsequent frame of the object segment;  
wherein the background modeling apparatus is adapted to provide as its  
20 output the projected location of the object segment in the subsequent frame in lieu of a segment from the subsequent frame determined by the background modeling apparatus to contain a possible object of interest or in the event that the background modeling apparatus is unable in the subsequent frame to locate any segment containing a possible object of  
25 interest; and,  
the object segment tracking apparatus further comprising:  
a matching apparatus adapted to match the location of an object segment in the current frame to one of a plurality of projected locations of the object segment in the current frame, which projections are based upon the location  
30 of the respective object segment in at least one prior frame;

a track provider adapted to receive and store the location of an object segment in the current frame and over a plurality of prior frames and adapted to provide the projections of the location of the object segment in a subsequent frame based upon the locations of the object segments in the current frame and the plurality of prior frames; and,

the vertical symmetry detector is adapted to compute the vertical symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given column  $i$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each column  $i$  on opposing sides of the horizontal axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the horizontal axis; and,

the horizontal symmetry detector is adapted to compute the horizontal symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given row  $j$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each row  $j$  on opposing sides of the vertical axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the vertical axis;

the background modeling apparatus is adapted to provide as its output the projected location of the object segment in the subsequent frame in order to override any conflict in the labeling of pixels in the subsequent frame as part of a segment containing a possible object of interest;

the feature set computation apparatus further comprising:  
a horizontal fuzzy set computation apparatus adapted to compute a fuzzy set value for each of a plurality of horizontal fuzzy sets each having a

selected weighting function applicable to a selected group of columns  
within the object segment, with the columns grouped according to position  
along the horizontal axis in the object segment; and,  
a vertical fuzzy set computation apparatus adapted to compute a fuzzy set value for  
5 each of a plurality of vertical fuzzy sets each having a selected weighting function  
applicable to a selected group of rows within the object segment, with the rows  
grouped according to position along the vertical axis in the object segment; and,  
the background modeling apparatus is adapted to isolate from a current  
frame the at least one segment of the current frame utilizing the video object plane  
10 extracted from the current frame.

39. A video detection apparatus adapted to detect and follow movement of a  
predefined object of interest within the video data of the output of a video camera  
encoded in frame-wise data, each frame occurring at sequential time intervals, and  
15 including the segmentation of at least one portion of the frame-wise data, an object  
segment, as potentially including the preselected object of interest, and including  
vertical edge pixels and horizontal edge pixels detected to be present within the  
object segment, comprising:

an edge symmetry detection unit comprising:  
20 a vertical symmetry detector adapted to compute the vertical symmetry of  
the set of vertical edge pixels and the set of horizontal edge pixels in each  
column about a horizontal axis passing through the object segment, and to  
produce a vertical symmetry value for columns within the object segment;  
a horizontal symmetry detector adapted to compute the horizontal  
25 symmetry of the set of vertical edge pixels and set of horizontal edge pixels  
in each row about a vertical axis passing through the object segment, and to  
produce a horizontal symmetry value for rows within the object segment;  
and,  
an edge symmetry feature set computation apparatus adapted to compute an  
30 edge symmetry feature set for the object segment based upon the vertical

symmetry values and the horizontal symmetry values; and,  
a background modeling unit comprising:  
a background modeling apparatus adapted to isolate from a current frame at  
least one segment of the current frame, each of the at least one segments  
5 containing a possible object of interest within the current frame, on a frame-  
wise basis, and to provide as an output each of the at least one segments;  
an object of interest classifying apparatus adapted to determine whether or  
not any segment of the at least one segments output from the background  
modeling apparatus includes a object of interest and to characterize any  
10 such segment as an object segment, utilizing at least in part the edge  
symmetry feature set;  
an object segment tracking apparatus adapted to track the location within  
the current frame of any object segment, and to determine a projected  
location of the object segment in a subsequent frame, and to provide the  
15 background modeling apparatus with the projected location in the  
subsequent frame of the object segment;  
wherein the background modeling apparatus is adapted to provide as its  
output the projected location of the object segment in the subsequent frame  
in lieu of a segment from the subsequent frame determined by the  
20 background modeling apparatus to contain a possible object of interest or in  
the event that the background modeling apparatus is unable in the  
subsequent frame to locate any segment containing a possible object of  
interest; and,  
the object segment tracking apparatus further comprising:  
25 a matching apparatus adapted to match the location of an object segment in  
the current frame to one of a plurality of projected locations of the object  
segment in the current frame, which projections are based upon the location  
of the respective object segment in at least one prior frame;  
a track provider adapted to receive and store the location of an object segment in  
30 the current frame and over a plurality of prior frames and adapted to provide the

projections of the location of the object segment in a subsequent frame based upon the locations of the object segments in the current frame and the plurality of prior frames; and,

the vertical symmetry detector is adapted to compute the vertical symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given column  $i$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each column  $i$  on opposing sides of the horizontal axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the horizontal axis; and,

the horizontal symmetry detector is adapted to compute the horizontal symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given row  $j$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each row  $j$  on opposing sides of the vertical axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the vertical axis;

the background modeling apparatus is adapted to provide as its output the projected location of the object segment in the subsequent frame in order to override any conflict in the labeling of pixels in the subsequent frame as part of a segment containing a possible object of interest;

the feature set computation apparatus further comprising:  
a horizontal fuzzy set computation apparatus adapted to compute a fuzzy set value for each of a plurality of horizontal fuzzy sets each having a selected weighting function applicable to a selected group of columns within the object segment, with the columns grouped according to position

along the horizontal axis in the object segment; and,  
a vertical fuzzy set computation apparatus adapted to compute a fuzzy set value for  
each of a plurality of vertical fuzzy sets each having a selected weighting function  
applicable to a selected group of rows within the object segment, with the rows  
5 grouped according to position along the vertical axis in the object segment; and,  
the background modeling apparatus is adapted to isolate from a current  
frame the at least one segment of the current frame utilizing the video object plane  
extracted from the current frame; and  
the horizontal fuzzy sets further comprising:  
10 a left extreme fuzzy set having a weighting function that is a constant value  
for a first selected number of columns from the left border of the object  
segment toward the vertical axis of the object segment and decreases to  
zero over a second selected number of columns toward the vertical axis if  
the object segment;  
15 a right extreme fuzzy set having a weighting function that is a constant  
value for a third selected number of columns from the right border of the  
object segment toward the vertical axis of the object segment and decreases  
to zero over a fourth selected number of columns toward the vertical axis of  
the object segment; and  
20 at least one horizontal internal fuzzy set having a weighting function that  
increases from zero to a peak value and decreases to zero as the columns  
contained in each such internal fuzzy set go from left to right across the  
object image;  
the vertical fuzzy sets further comprising:  
25 a bottom extreme fuzzy set having a weighting function that is a constant  
value for a fifth selected number of rows from the bottom border of the  
object segment toward the horizontal axis of the object segment and  
decreases to zero over a sixth selected number of rows toward the  
horizontal axis if the object segment;  
30 a top extreme fuzzy set having a weighting function that is a constant value



for a seventh selected number of columns from the top border of the object segment toward the horizontal axis of the object segment and decreases to zero over an eighth selected number of rows toward the horizontal axis of the object segment; and,

- 5 at least one vertical internal fuzzy set having a weighting function that increases from zero to a peak value and decreases to zero as the rows contained in each such vertical internal fuzzy set go from bottom to top across the object image.

40. A video detection apparatus adapted to detect and follow movement of a  
10 predefined object of interest within the video data of the output of a video camera encoded in frame-wise data, each frame occurring at sequential time intervals, and including the segmentation of at least one portion of the frame-wise data, an object segment, as potentially including the preselected object of interest, and including vertical edge pixels and horizontal edge pixels detected to be present within the  
15 object segment, comprising:

an edge symmetry detection unit comprising:

- a vertical symmetry detector adapted to compute the vertical symmetry of the set of vertical edge pixels and the set of horizontal edge pixels in each column about a horizontal axis passing through the object segment, and to  
20 produce a vertical symmetry value for columns within the object segment;  
a horizontal symmetry detector adapted to compute the horizontal symmetry of the set of vertical edge pixels and set of horizontal edge pixels in each row about a vertical axis passing through the object segment, and to produce a horizontal symmetry value for rows within the object segment;

25 and,

an edge symmetry feature set computation apparatus adapted to compute an edge symmetry feature set for the object segment based upon the vertical symmetry values and the horizontal symmetry values; and,

a background modeling unit comprising:

a background modeling apparatus adapted to isolate from a current frame at least one segment of the current frame, each of the at least one segments containing a possible object of interest within the current frame, on a frame-wise basis, and to provide as an output each of the at least one segments;

5 an object of interest classifying apparatus adapted to determine whether or not any segment of the at least one segments output from the background modeling apparatus includes a object of interest and to characterize any such segment as an object segment, utilizing at least in part the edge symmetry feature set;

10 an object segment tracking apparatus adapted to track the location within the current frame of any object segment, and to determine a projected location of the object segment in a subsequent frame, and to provide the background modeling apparatus with the projected location in the subsequent frame of the object segment;

15 wherein the background modeling apparatus is adapted to provide as its output the projected location of the object segment in the subsequent frame in lieu of a segment from the subsequent frame determined by the background modeling apparatus to contain a possible object of interest or in the event that the background modeling apparatus is unable in the

20 subsequent frame to locate any segment containing a possible object of interest; and,

the object segment tracking apparatus further comprising:

a matching apparatus adapted to match the location of an object segment in the current frame to one of a plurality of projected locations of the object

25 segment in the current frame, which projections are based upon the location of the respective object segment in at least one prior frame;

a track provider adapted to receive and store the location of an object segment in the current frame and over a plurality of prior frames and adapted to provide the projections of the location of the object segment in a subsequent frame based upon

30 the locations of the object segments in the current frame and the plurality of prior

frames; and,

the vertical symmetry detector is adapted to compute the vertical symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given column  $i$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each column  $i$  on opposing sides of the horizontal axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the horizontal axis; and,

the horizontal symmetry detector is adapted to compute the horizontal symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given row  $j$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each row  $j$  on opposing sides of the vertical axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the vertical axis;

the background modeling apparatus is adapted to provide as its output the projected location of the object segment in the subsequent frame in order to override any conflict in the labeling of pixels in the subsequent frame as part of a segment containing a possible object of interest;

the feature set computation apparatus further comprising:

a horizontal fuzzy set computation apparatus adapted to compute a fuzzy set value for each of a plurality of horizontal fuzzy sets each having a selected weighting function applicable to a selected group of columns within the object segment, with the columns grouped according to position along the horizontal axis in the object segment; and,

a vertical fuzzy set computation apparatus adapted to compute a fuzzy set value for

each of a plurality of vertical fuzzy sets each having a selected weighting function applicable to a selected group of rows within the object segment, with the rows grouped according to position along the vertical axis in the object segment; and, the background modeling apparatus is adapted to isolate from a current frame the at least one segment of the current frame utilizing the video object plane extracted from the current frame; and

the horizontal fuzzy sets further comprising:

a left extreme fuzzy set having a weighting function that is a constant value for a first selected number of columns from the left border of the object segment toward the vertical axis of the object segment and decreases to zero over a second selected number of columns toward the vertical axis if the object segment;

a right extreme fuzzy set having a weighting function that is a constant value for a third selected number of columns from the right border of the object segment toward the vertical axis of the object segment and decreases to zero over a fourth selected number of columns toward the vertical axis of the object segment; and

at least one horizontal internal fuzzy set having a weighting function that increases from zero to a peak value and decreases to zero as the columns contained in each such internal fuzzy set go from left to right across the object image;

the vertical fuzzy sets further comprising:

a bottom extreme fuzzy set having a weighting function that is a constant value for a fifth selected number of rows from the bottom border of the object segment toward the horizontal axis of the object segment and decreases to zero over a sixth selected number of rows toward the horizontal axis if the object segment;

a top extreme fuzzy set having a weighting function that is a constant value for a seventh selected number of columns from the top border of the object segment toward the horizontal axis of the object segment and decreases to

zero over an eighth selected number of rows toward the horizontal axis of the object segment; and,  
at least one vertical internal fuzzy set having a weighting function that increases from zero to a peak value and decreases to zero as the rows  
5 contained in each such vertical internal fuzzy set go from bottom to top across the object image; and,  
the at least one segment of the current frame is a bounding box.

41. A video detection apparatus adapted to detect and follow movement of a  
10 predefined object of interest within the video data of the output of a video camera encoded in frame-wise data, each frame occurring at sequential time intervals, and including the segmentation of at least one portion of the frame-wise data, an object segment, as potentially including the preselected object of interest, and including vertical edge pixels and horizontal edge pixels detected to be present within the  
15 object segment, comprising:  
an edge symmetry detection unit comprising:  
a vertical symmetry detector adapted to compute the vertical symmetry of the set of vertical edge pixels and the set of horizontal edge pixels in each column about a horizontal axis passing through the object segment, and to  
20 produce a vertical symmetry value for columns within the object segment;  
a horizontal symmetry detector adapted to compute the horizontal symmetry of the set of vertical edge pixels and set of horizontal edge pixels in each row about a vertical axis passing through the object segment, and to produce a horizontal symmetry value for rows within the object segment;  
25 and,  
an edge symmetry feature set computation apparatus adapted to compute an edge symmetry feature set for the object segment based upon the vertical symmetry values and the horizontal symmetry values; and,  
a background modeling unit comprising:

a background modeling apparatus adapted to isolate from a current frame at least one segment of the current frame, each of the at least one segments containing a possible object of interest within the current frame, on a frame-wise basis, and to provide as an output each of the at least one segments;

5 an object of interest classifying apparatus adapted to determine whether or not any segment of the at least one segments output from the background modeling apparatus includes a object of interest and to characterize any such segment as an object segment, utilizing at least in part the edge symmetry feature set;

10 an object segment tracking apparatus adapted to track the location within the current frame of any object segment, and to determine a projected location of the object segment in a subsequent frame, and to provide the background modeling apparatus with the projected location in the subsequent frame of the object segment;

15 wherein the background modeling apparatus is adapted to provide as its output the projected location of the object segment in the subsequent frame in lieu of a segment from the subsequent frame determined by the background modeling apparatus to contain a possible object of interest or in the event that the background modeling apparatus is unable in the

20 subsequent frame to locate any segment containing a possible object of interest; and,

the object segment tracking apparatus further comprising:

a matching apparatus adapted to match the location of an object segment in the current frame to one of a plurality of projected locations of the object

25 segment in the current frame, which projections are based upon the location of the respective object segment in at least one prior frame;

a track provider adapted to receive and store the location of an object segment in the current frame and over a plurality of prior frames and adapted to provide the projections of the location of the object segment in a subsequent frame based upon

30 the locations of the object segments in the current frame and the plurality of prior

frames; and,

- the vertical symmetry detector is adapted to compute the vertical symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given column  $i$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each column  $i$  on opposing sides of the horizontal axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the horizontal axis; and,
- the horizontal symmetry detector is adapted to compute the horizontal symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given row  $j$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each row  $j$  on opposing sides of the vertical axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the vertical axis;
- the background modeling apparatus is adapted to provide as its output the projected location of the object segment in the subsequent frame in order to override any conflict in the labeling of pixels in the subsequent frame as part of a segment containing a possible object of interest;
- the feature set computation apparatus further comprising:
- a horizontal fuzzy set computation apparatus adapted to compute a fuzzy set value for each of a plurality of horizontal fuzzy sets each having a selected weighting function applicable to a selected group of columns within the object segment, with the columns grouped according to position along the horizontal axis in the object segment; and,
- a vertical fuzzy set computation apparatus adapted to compute a fuzzy set value for

each of a plurality of vertical fuzzy sets each having a selected weighting function applicable to a selected group of rows within the object segment, with the rows grouped according to position along the vertical axis in the object segment; and,  
the background modeling apparatus is adapted to isolate from a current  
5 frame the at least one segment of the current frame utilizing the video object plane extracted from the current frame; and  
the horizontal fuzzy sets further comprising:  
a left extreme fuzzy set having a weighting function that is a constant value for a first selected number of columns from the left border of the object  
10 segment toward the vertical axis of the object segment and decreases to zero over a second selected number of columns toward the vertical axis if the object segment;  
a right extreme fuzzy set having a weighting function that is a constant value for a third selected number of columns from the right border of the  
15 object segment toward the vertical axis of the object segment and decreases to zero over a fourth selected number of columns toward the vertical axis of the object segment; and  
at least one horizontal internal fuzzy set having a weighting function that increases from zero to a peak value and decreases to zero as the columns  
20 contained in each such internal fuzzy set go from left to right across the object image;  
the vertical fuzzy sets further comprising:  
a bottom extreme fuzzy set having a weighting function that is a constant value for a fifth selected number of rows from the bottom border of the  
25 object segment toward the horizontal axis of the object segment and decreases to zero over a sixth selected number of rows toward the horizontal axis if the object segment;  
a top extreme fuzzy set having a weighting function that is a constant value for a seventh selected number of columns from the top border of the object  
30 segment toward the horizontal axis of the object segment and decreases to



zero over an eighth selected number of rows toward the horizontal axis of the object segment; and,  
at least one vertical internal fuzzy set having a weighting function that increases from zero to a peak value and decreases to zero as the rows  
5 contained in each such vertical internal fuzzy set go from bottom to top across the object image;  
the at least one segment of the current frame is a bounding box; and,  
the columns associated with each of the horizontal fuzzy sets are overlapping into respective adjacent horizontal fuzzy sets; and,  
10 the rows associated with each of the vertical fuzzy sets are overlapping into respective adjacent vertical fuzzy sets.

42. A video detection apparatus adapted to detect and follow movement of a predefined object of interest within the video data of the output of a video camera  
15 encoded in frame-wise data, each frame occurring at sequential time intervals, and including the segmentation of at least one portion of the frame-wise data, an object segment, as potentially including the preselected object of interest, and including vertical edge pixels and horizontal edge pixels detected to be present within the object segment, comprising:  
20 an edge symmetry detection unit comprising:  
a vertical symmetry detector adapted to compute the vertical symmetry of the set of vertical edge pixels and the set of horizontal edge pixels in each column about a horizontal axis passing through the object segment, and to produce a vertical symmetry value for columns within the object segment;  
25 a horizontal symmetry detector adapted to compute the horizontal symmetry of the set of vertical edge pixels and set of horizontal edge pixels in each row about a vertical axis passing through the object segment, and to produce a horizontal symmetry value for rows within the object segment;  
and,  
30 an edge symmetry feature set computation apparatus adapted to compute an

edge symmetry feature set for the object segment based upon the vertical symmetry values and the horizontal symmetry values; and,  
a background modeling unit comprising:  
a background modeling apparatus adapted to isolate from a current frame at  
5 least one segment of the current frame, each of the at least one segments containing a possible object of interest within the current frame, on a frame-wise basis, and to provide as an output each of the at least one segments;  
an object of interest classifying apparatus adapted to determine whether or not any segment of the at least one segments output from the background  
10 modeling apparatus includes a object of interest and to characterize any such segment as an object segment, utilizing at least in part the edge symmetry feature set;  
an object segment tracking apparatus adapted to track the location within the current frame of any object segment, and to determine a projected  
15 location of the object segment in a subsequent frame, and to provide the background modeling apparatus with the projected location in the subsequent frame of the object segment;  
wherein the background modeling apparatus is adapted to provide as its output the projected location of the object segment in the subsequent frame  
20 in lieu of a segment from the subsequent frame determined by the background modeling apparatus to contain a possible object of interest or in the event that the background modeling apparatus is unable in the subsequent frame to locate any segment containing a possible object of interest; and,  
25 the object segment tracking apparatus further comprising:  
a matching apparatus adapted to match the location of an object segment in the current frame to one of a plurality of projected locations of the object segment in the current frame, which projections are based upon the location of the respective object segment in at least one prior frame;  
30 a track provider adapted to receive and store the location of an object segment in

the current frame and over a plurality of prior frames and adapted to provide the projections of the location of the object segment in a subsequent frame based upon the locations of the object segments in the current frame and the plurality of prior frames; and,

5           the vertical symmetry detector is adapted to compute the vertical symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given column  $i$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each column  $i$  on opposing sides of the horizontal axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal edge  
10           pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the horizontal axis; and,

              the horizontal symmetry detector is adapted to compute the horizontal  
15           symmetry value of at least one of the set of horizontal edges or the set of vertical edges in a given row  $j$  as the ratio of the number of horizontal edge pixels or vertical edge pixels, respectively, in each row  $j$  on opposing sides of the vertical axis, independent of which side has more horizontal edge pixels or vertical edge pixels, respectively, expressed as a number between 0, if there are no horizontal  
20           edge pixels or no vertical edge pixels, respectively, on either side of the horizontal axis and 1.0 if there are, respectively, an equal number of horizontal edge pixels or vertical edge pixels, respectively on both sides of the vertical axis;

              the background modeling apparatus is adapted to provide as its output the projected location of the object segment in the subsequent frame in order to  
25           override any conflict in the labeling of pixels in the subsequent frame as part of a segment containing a possible object of interest;

              the feature set computation apparatus further comprising:

              a horizontal fuzzy set computation apparatus adapted to compute a fuzzy  
              set value for each of a plurality of horizontal fuzzy sets each having a  
30           selected weighting function applicable to a selected group of columns

within the object segment, with the columns grouped according to position along the horizontal axis in the object segment; and,

a vertical fuzzy set computation apparatus adapted to compute a fuzzy set value for each of a plurality of vertical fuzzy sets each having a selected weighting function

5 applicable to a selected group of rows within the object segment, with the rows grouped according to position along the vertical axis in the object segment; and,

the background modeling apparatus is adapted to isolate from a current frame the at least one segment of the current frame utilizing the video object plane extracted from the current frame; and

10 the horizontal fuzzy sets further comprising:

a left extreme fuzzy set having a weighting function that is a constant value for a first selected number of columns from the left border of the object segment toward the vertical axis of the object segment and decreases to zero over a second selected number of columns toward the vertical axis if

15 the object segment;

a right extreme fuzzy set having a weighting function that is a constant value for a third selected number of columns from the right border of the object segment toward the vertical axis of the object segment and decreases to zero over a fourth selected number of columns toward the vertical axis of

20 the object segment; and

at least one horizontal internal fuzzy set having a weighting function that increases from zero to a peak value and decreases to zero as the columns contained in each such internal fuzzy set go from left to right across the object image;

25 the vertical fuzzy sets further comprising:

a bottom extreme fuzzy set having a weighting function that is a constant value for a fifth selected number of rows from the bottom border of the object segment toward the horizontal axis of the object segment and decreases to zero over a sixth selected number of rows toward the

30 horizontal axis if the object segment;

a top extreme fuzzy set having a weighting function that is a constant value for a seventh selected number of columns from the top border of the object segment toward the horizontal axis of the object segment and decreases to zero over an eighth selected number of rows toward the horizontal axis of the object segment; and,

5       at least one vertical internal fuzzy set having a weighting function that increases from zero to a peak value and decreases to zero as the rows contained in each such vertical internal fuzzy set go from bottom to top across the object image;

10       the at least one segment of the current frame is a bounding box;

      the columns associated with each of the horizontal fuzzy sets are overlapping into respective adjacent horizontal fuzzy sets; and,

      the rows associated with each of the vertical fuzzy sets are overlapping into respective adjacent vertical fuzzy sets; and,

15       the feature set computation apparatus further comprising a fuzzy set edge value score computing apparatus adapted to compute a fuzzy set edge value based upon the respective horizontal edge value or vertical edge value for the respective column or row and the respective horizontal fuzzy set weighting function value for the respective column or the respective vertical fuzzy set weighting function for the

20       respective row.